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THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR
C. A. CHANT
University of Toronto, Toronto

ASSOCIATE EDITORS
J. S. PLASKETT
Director of the Dominion Astrophysical Observatory, Victoria, B.C.
SIR FREDERIC STUPART
Director of the Meteorological Service of Canada, Toronto
R. MELDRUM STEWART
Director of the Dominion Observatory, Ottawa

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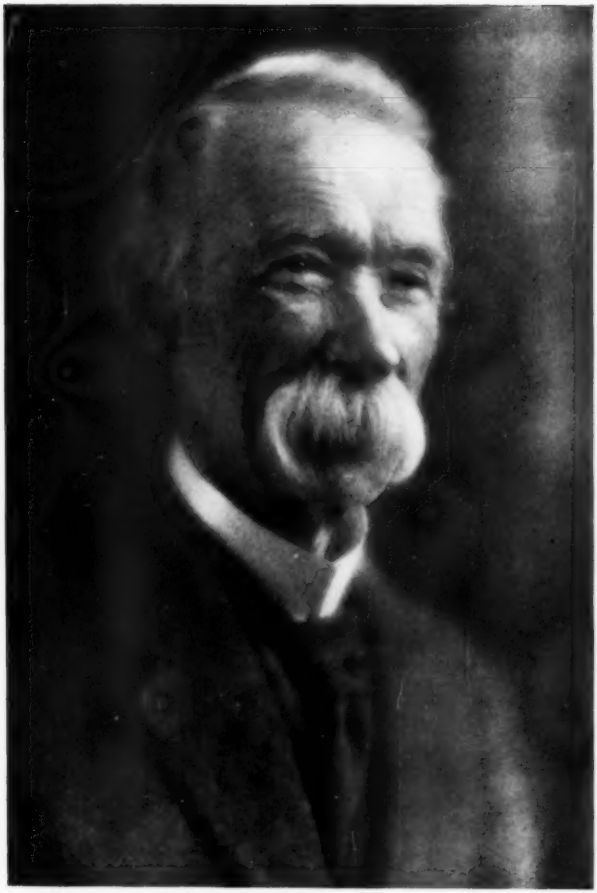

William Bruce (1832-1927)
Photograph taken in 1925

PLATE II

ELMWOOD OBSERVATORY:
the Private Observatory of the late William Bruce, Hamilton, Ont.

THE JOURNAL
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ROYAL ASTRONOMICAL SOCIETY
OF CANADA

Vol. XXI, No. 4 APRIL-MAY, 1927 Whole No. 164

Journal of the Royal Astronomical Society of Canada, 1927.

WILLIAM BRUCE, 1832-1927

By C. A. Chant

A NOTABLE link with the past was severed when William Bruce died at his long-time home in Hamilton on March 7 last. He had lived there almost continuously for ninety years and was a familiar figure on its streets.

William Bruce was born on November 7, 1832, on Unst one of the Shetland Isles. One of his ancestors, Laurence Bruce, whose valour was rewarded by the Crown, was the founder of the Castle of Muness on the Isle of Unst. His father, Magnus Bruce, with his wife and family came to Canada in 1836. William was the oldest of twelve children and he survived them all. When the family settled in Hamilton it was little more than a hamlet; now its population is about 125,000.

At the age of seven William went to the old Grammar School conducted by Dr. Tassie and Dr. Rae. At sixteen he entered the iron foundry of Fisher and McQuesten as an apprentice moulder. But his mind was active and he was fond of good books, and as a youth he joined the first mechanics' library. He also attended all the good lectures he could; and during his spare hours he studied mechanical and architectural drawing under an architect. In addition he became proficient in Pitman's system of shorthand.

Later Mr. Bruce attended Oberlin College, Ohio, where he studied the classics and commercial practice. Returning to Hamilton about 1858 he was appointed writing master in the old Central School, and some time afterwards he established an evening commercial school. In 1867 he became a patent attorney, and being a beautiful penman and having artistic ability he also undertook to do engrossing. In this he was decidedly successful and many

finely illuminated addresses produced by him were sent to notable people all over the world, among them being Queen Victoria and King Edward VII.

Mr. Bruce was interested in all good causes and about twenty-five years ago he began to give special attention to astronomy. At Elmwood, his beautiful home among the trees on the mountain top, he had a studio with a dome upon it. Here he installed a 5-inch refractor and a 6-inch reflector. The Hamilton Centre of the Royal Astronomical Society of Canada was organized by Rev. D. B. Marsh, when residing in Hamilton, and Mr. Bruce was always an officer, being president for some time. For several years before his death he was 1st vice-president of the general organization, the Royal Astronomical Society of Canada. He cordially invited the citizens to his observatory and many availed themselves of the opportunity to have a view of the heavenly bodies through a good instrument.

Mr. Bruce in 1853 married Janet Blair, daughter of William Blair, who came to Canada at about the same time as the Bruces did. There were three children. Irwin died at the age of 21. The second son Blair became a distinguished artist, one of the very best produced in Canada, and internationally famous. Some of his pictures are in the Hamilton Art Gallery and two are in the National Gallery at Ottawa. He died in Sweden in 1906. The present writer well remembers a visit he and some of his family made to Hamilton at the invitation of Mr. Bruce in order to see the pictures in the Gallery. To have the proud father give the circumstances under which each picture was produced and to have their special features explained by one so able to do it, was a real privilege.

The third child is Mrs. John Walkden, with whom he has resided many years at the old home. Mrs. Bruce died in 1904.

Mr. Bruce had almost unbroken good health. In his time he was noted as a yachtsman, a football player, a swimmer and a graceful skater. His erect figure and smart step were familiar on the streets of the city. He attributed his long life to his moderation in all things. He never touched liquor, did not drink tea or coffee, and spent much time out of doors. He leaves behind him memories of a life well spent in endeavours to improve his own mind and to promote the intellectual and aesthetic interests of the community.

THE LIFE OF SIR ISAAC NEWTON—1642-1727*

By John C. Goodfellow

Introduction

This present year marks the 200th anniversary of the death of one of the very greatest ornaments of the human race—Sir Isaac Newton. His life and work are very intimately connected with the history and progress of astronomy. We do well to remember one who is universally known as "the Prince of Philosophers" and whom, in the days of his flesh, even his sovereign delighted to honour.

It would be tedious to enumerate the long list of definitions of the word "genius". Some have called it "An infinite capacity for taking pains." Some have called it a gift for hard work. The fact of the matter is we do not know very much about genius. But we recognise it, and we all have in our hearts an inherent reverence for the man of supreme genius. Such a man was Isaac Newton.

It is quite true that we often find, coincident with the presence of genius in the human mind, a strange simplicity, or eccentricity. Sometimes genius makes a man irritable. Sometimes the genius is imprisoned in a castle of intellect, surrounded by a moat, and few there be who find access to it. Sometimes the eccentricities of genius endear a man to his friends. Newton was one of the most lovable of men.

I have tried to arrange my material under four headings, and to make these correspond with the answers to four very simple, and natural questions, When? Where? What? and Why?

I. Historical

Our first question asks when Newton lived. The answer calls for a rapid survey of the times in which he lived. Newton was born

*Abridgment of an address before the Victoria Centre, Tuesday, March 15, 1927.

on Christmas Day, 1642. He died in 1727, on March the 20th. Our survey then must cover the intervening 85 years.

(*a*) *Political.* We might very well preface the political history of the times with the opening sentence of "The Tale of Two Cities." It was the best of times, it was the worst of times, etc.

1. France was the dominant power on the continent. The supremacy of Spain had not survived the disaster to her Armada in the year 1588, during the war with England of Elizabeth's time. Cardinal Richelieu died in December, 1642. Richelieu is known to history as "The Iron Cardinal". He made the monarchy the second power in France, and the first power in Europe. He was the Lloyd George of the Thirty Years War. Louis XIII appointed Cardinal Mazarin to carry on the policies that Richelieu had initiated. Within six months Louis himself died. Then began one of the longest reigns in all history—Louis XIV, 1643-1715. Mazarin died in 1661, and thereafter Louis reigned more absolutely than any French king had done before.

2. In Holland the Dutch were rallying to the standard of William, Prince of Orange, in their long fight for political freedom, and independence.

3. If we cross the Channel, we find that Newton lived during the reigns of no fewer than eight rulers.

When Newton was born, Charles I was King of England. The reign of Charles I was marked by recurring strife with his parliaments. That strife culminated in civil war. Charles was executed in 1649.

England had no king for eleven years, but she was not without a ruler, for during the Commonwealth, Cromwell made the name of England respected among the nations of Europe. It was the time of Milton. Bunyan was still a young man.

Cromwell's second son, Richard, soon resigned the Protectorate. Then Charles II reigned for 25 years. The great plague devastated England in 1665. The great fire of London took place in 1666. The following year the Dutch navy sailed up the River Thames. The year 1670 saw the beginning of the Hudson's Bay Company. Charles II was secretly in the service, and in the pay, of Louis XIV of France.

James II, his successor, reigned barely four years. He carried

on the policy of Charles II, and maintained the secret alliance with France. When this and other things were discovered, William, Prince of Orange, was invited to cross the Channel, and accept the crown of England.

William and Mary reigned jointly till 1694, and then the former reigned alone till 1702. Queen Anne reigned from 1702-1714. That was the period of the War of the Spanish succession. Marlborough made British arms famous on many a battlefield of Europe. England and Scotland became the United Kingdom in 1707. Then George I ascended the throne, and he ruled till 1727—the year in which Newton died.

(*b*) *Religious.* It is difficult to say much about the church history of the period. The Reformation, led by Martin Luther and others, that shook the political foundations of Europe, had been succeeded by the Counter-Reformation under the direction of Ignatius Loyola. The pages of church history, during Newton's lifetime, were largely spoiled by persecutions. These were not confined to any one sect or party. In England the age of Puritanism had been followed by an age of licence. But one notes with satisfaction that as Newton advanced in years, though heretics increased martyrdoms decreased. Indeed there was a growing spirit of agnosticism. Men were beginning to question Authority. At the same time thousands continued to believe in witchcraft. But on the whole there was a very distinct advance towards the spirit of toleration in religion and freedom in thought. It was a time of commercial and colonial expansion, and men's minds were correspondingly broadened by wider geographical horizons.

(*c*) *Scientific.* The Renaissance expressed itself in many ways, and one of these was in the new impetus it gave to the spirit of enquiry.

Copernicus died just 100 years before Newton was born. He is regarded today as the Father of Modern Astronomy. He laid the axe to the root of the old Ptolemaic system, which taught that the earth was the centre of the universe.

Kepler discovered his famous laws relating to the movements of the heavenly bodies.

Then came Galileo, and by means of the newly invented telescope, he was able to give demonstrable proof to many facts

that had hitherto been regarded only as theories. Galileo died in January 1642.

The new theories met with much opposition from conservative clergymen. Nor have centuries quite sufficed to teach all that Theology and Astronomy are sister Sciences, both of which may minister to pure Religion.

During Newton's lifetime the Royal Society in England, and the Academy of Science in France were organized.

II. Geographical

It is with a feeling of relief that one turns to think of some of the quiet scenes of rural England. In spite of all the hurly-burly of history thousands lived quiet, and peaceful, and useful lives in secluded hamlets, blissfully unconscious of the turns of politics, of the latest war, of religious controversy, and of the incessant fight for scientific truth. There is indeed throughout all Newton's life this calm quiet, peaceful existence in spite of the quickly moving events of history. Perhaps we can best get the atmosphere in which Newton lived his life, by letting our minds dwell on the scenes he learned to love.

Lincolnshire was the part of England that Newton learned to love when he was a boy. It is one of the counties on the East coast, facing the North Sea. For our purpose we must mention three places in Lincolnshire—Woolsthorpe, Grantham, and Lincoln.

Lincoln is a fine old Cathedral town. The Cathedral and its bell are famous the world over. Grantham is a quiet village. It has the usual church, school, and inn, and is set in the midst of gentle vales that suggest peace. Woolsthorpe is only a hamlet. Its population is very small. But it is a place of pilgrimage to many who seek to do honour to Newton's memory.

Newton was born in Woolsthorpe. As a boy he went to school in Grantham. He often visited Lincoln.

Cambridge is familiar to many people who have never travelled that far. Long before Newton's time, it was famous as a University centre. Newton was pre-eminent among her scholars and teachers. It is difficult to mention the name of London without saying too much, or too little. London was devastated by the plague during

Newton's lifetime. During the first quarter of the 18th century Newton was a familiar figure in London. The gatherings of the Royal Society were often held in the Grecia coffee-house. Newton would be there. In Parliament too, his face was familiar. He was a visitor to Greenwich, where the first Royal Observatory was established in 1675. At the Mint he laboured for years. He was a welcome guest at the Royal Court. He was to find a last resting place in Westminster Abbey. All these places—and many more—were known to, and loved by Isaac Newton.

He often made the journey from London or from Cambridge to the Midlands. Travelling was a slow, painful, and often dangerous affair, in the 17th century.

Those who would really understand the background of Newton's life must know something not only about the history of the period, but also about the social life and customs of the age.

III. Biographical

Newton, as I have said, was born on Christmas Day, 1642, in the village of Woolsthorpe, in the county of Lincoln. Our hero was called after his father, who died before young Isaac was born.

Schools—Newton was one of the frailest pieces of humanity that ever saw the light of day. In after years he used to quote his mother's saying that he was so small that they might have put him in a quart mug. He was hardly expected to live. But his mother determined that he should live, and the genius of Newton was saved for the world. When he was three years old his mother married again. She married the Rev. Barnabas Smith, with whom she went to live at North Witham. Young Newton was left in the care of his maternal grandmother. The child grew in wisdom, and stature, and in favour with God and man.

While still a lad he attended a couple of village schools—first at Skillington and then at Stoke—and then he was sent to the public school at Grantham. He was not particularly bright at his studies. One day a boy who was above him in his class gave him a severe kick in the stomach. Newton had a novel way of returning the compliment, for he studied incessantly till he had made himself head of the class, thus leaving his persecutor far behind.

That kick stimulated our young hero to habits of industry, and application, that never forsook him in after years. The mechanical turn of Newton's genius displayed itself at an early age, and amongst other things he made a water clock, a windmill, and a sun-dial. He also began to interest himself in astronomy, attempted some poetry, and was fond of drawing.

When Newton was in his 14th year his stepfather died. Mrs. Smith, with her three children, returned to Woolsthorpe, and settled down on the little farm. Newton was taken from school, and was set to learn farming. But it was soon apparent that he was not destined to be a farmer, and his mother was wise enough to send him back to the Grantham School, there to prepare for College.

Cambridge—In 1661 Newton was admitted to Trinity College, Cambridge.

His genius for mathematics soon asserted itself. He took his Bachelor's degree in 1665. At that time the plague was ravaging in the south of England. London was full of weird noises, and gruesome sights. Grass grew in the streets. Cambridge did not escape. Trinity College was closed. Newton retired to Woolsthorpe.

"1666" has been called "The Year of Wonders"—*Annus Mirabilis*. But the most wonderful event of all was when the apple fell, as Newton was sitting in his garden at Woolsthorpe. Newton was only twenty-four—just an overgrown boy, yet the falling apple started in his mind a train of thought that was destined to have a lasting effect on the history and progress of mankind.

Newton returned to Trinity, and in 1668 he received the degree of Master of Arts. In the following year he was appointed Professor of Mathematics. His first lectures were on Optics. By this time he had already laid the foundation of his great discoveries in mathematics, in optics, and in astronomy.

He was made a Fellow of the Royal Society in 1672. In that year he began his immortal work, known as the "Principia". While the "Principia" was being completed an event happened that brought Newton into the limelight. James II insisted that a friend of his receive the M.A. degree, without taking the customary oath of allegiance. The University authorities refused and Newton was one of those who were sent to uphold the dignity of the University before the Court of High Commission, and the bloody Judge Jeffreys.

London—After this he was sent to London as member of Parliament for the University. Macaulay draws a vivid picture of the Parliament that sat during the Interregnum. "Among the . . . . members appeared the majestic forehead, and pensive face of Isaac Newton . . . . he sate there, in his modest greatness, the unobtrusive, but unflinching friend of civil and religious freedom."

In 1694 he was made Warden of the Mint, and a few years later, Master of the Mint, with a handsome salary of between twelve and fifteen hundred pounds a year. He was elected President of the Royal Society in 1703—an office to which he was elected annually till 1727, the year of his death.

He was knighted by Queen Anne in 1705. The event was marked at Cambridge by a great banquet, which cost the University $5000.

In 1713 a new edition of the "Principia" appeared—in its present form. In 1727—on the 20th of the March—the great Philosopher passed away.

Such are the main details of Newton's 85 years.

Scientific Work. We may now go back over some of the ground we have covered so quickly, and consider some of the remarkable discoveries that were the outcome of Newton's studies. As we have said he distinguished himself in mathematics, optics, and astronomy.

1. *Mathematics*—Newton did not love mathematics merely for the sake of mathematics, but because for him it was the key with which he could unlock the secrets that were bound up in the mystery of life, and in the mighty motions of the universe. He was still in his twenties when he developed his methods of expanding functions in series, and began his invention of fluxions. There was a long controversy over the discovery of the differential calculus. Newton and Leibnitz both claimed credit for it. The judgment of posterity has been that Newton was the first discoverer, and that Leibnitz was independently the second.

2. *Optics*—On his appointment as Lucasian Professor of Mathematics his first lectures were on the subject of Optics. He had already been of great assistance to Dr. Barrow, who resigned his chair in favor of Newton. He had made some important discoveries regarding the nature of light. It was in the year of the

great fire that he was experimenting with the prism, and by means of a hole in a shutter, admitted a ray of light, which he allowed to pass through the prism, thus breaking light up into its component parts, or colours. Then by means of another hole in the screen he was able to isolate any single colour, and receive it on to a second screen. Newton was the first to ascertain that the different rays of light had different degrees of refrangibility. He was the first to show that all the colours refracted by the prism entered into the composition of white light. This may not seem an epoch making discovery to schoolboys today, but it required the mind of Newton to demonstrate it.

This led Newton to experiment with the telescope, which, in his day, was a very crude affair. He invented the reflecting telescope, still known as the Newtonian reflector.

Gravitation—But his greatest claim to fame lies in the principles enunciated in the immortal "Principia". Copernicus, Kepler, and Galileo, all helped to prepare the way for Newton. Copernicus had shifted the centre of the universe from the earth to the sun. Thereafter the universe came to be regarded as helio-centric, and not geo-centric. Kepler had ascertained the laws of the motions of the planets. Galileo had practically invented celestial mechanics. It remained for Newton to co-ordinate the results of genius.

Newton applied the lesson of the falling apple to the motion of the moon. But the results of calculation did not support the theory he had conceived. As a matter of fact the measurement of the earth, as Newton had it, was at fault, and that upset his calculations.

Newton was disappointed and, for a time, turned his mind to other studies. But in 1679 the French mathematician, Picard, gave a more correct estimate of the size of the earth. When Newton learned of this he resumed his calculations. When it became evident to his mind that his law was verified, it is said that he became so excited that he could hardly carry on his work.

In spite of all this he does not appear to have considered publishing the results of his investigations. The "Principia" came to light quite by accident. In 1684 a discussion arose between Wren, and Hooke, and Halley, concerning the law of inverse square as applied to gravity. Hooke asserted that he had the solution.

But he would not produce it. Halley, therefore, went to Cambridge to consult Newton. Thus he discovered the first part of the "Principia". Halley reported to the Royal Society, and Newton was asked for the manuscript. When it was completed the book was published at Halley's expense.

The world owes a very great debt to Halley, for discovering Newton's work, for urging its completion, and for publishing it.

The "Principia" consists of three books. The first two are "On the Motions of Bodies". The third is "On the System of the World". It is not our purpose to go into the details of these books. They constitute the noblest, and most enduring monuments to Newton's genius.

Many-sided Genius—We have not, by any means covered every phase of Newton's many-sided genius. Reference must be made to his studies in Chemistry, and to his work in Theology.

As Master of the Mint Newton was able to bring into play his knowledge of chemistry. The coinage had been much debased, and he set himself the task of putting this right. He had made many experiments with the nature and properties of heat, and acids.

More especially in his later years Newton spent much time in reading and writing theological works. These are seldom read now, except by the curious, yet they reveal a mind that had a singular grasp of the great realities of life. Newton was a humble, devout, sincere Christian.

Personality. We must say something about the personality of the man who so impressed his own, and succeeding ages, with his genius.

Physically, he was about middle-size. In later life he was inclined to be corpulent. He is described as having a lively, and piercing eye, and a fine head of silver white hair. Macaulay refers to his majestic forehead, and pensive face. His bearing was marked by a grace, and simple dignity, that made him loved wherever he went. He lived frugally, and always in the same modest, dignified simplicity, together with his favorite niece, and her husband.

We may well stand in awe when we consider the mighty intellect of Newton. Macaulay says: "In Newton two kinds of intellectual power which have little in common, and which are not often found together in a high degree of vigour, but which neverthe-

less are equally necessary in the most sublime department of physics, were united, as they have never been before or since." Of course Macaulay was fond of sweeping superlatives, but here for once we are inclined to think that he did not overstate the case. "In no other mind" Macaulay continues, "have the demonstrative faculty, and the inductive faculty co-existed in such supreme excellence and perfect harmony."

But Newton was no mere human calculating machine. As we said at the commencement he was one of the most lovable of men. His complete effacement of self, his modesty, his sincerity, his honesty, his industry, and perseverance, all united to make him a man amongst men.

Many stories are told of his absorption in intellectual pursuits. It is said that often when he arose in the morning his mind was instantly at work, so that he would sit on his bedside, and forget to dress himself. Sometimes he forgot to take his meals. His health, and his domestic affairs, had all to be looked after by his relatives.

IV. Progress

Our task is nearly done. I have tried to sketch the historical background, to tell of the places where Newton lived, to give you some details of his long life, and of his discoveries, and of his personality.

. . . . . It remains only to try and link up his life and work with the subsequent progress which he made possible, in more than one field of science.

Mathematics—In the realm of mathematics by his discoveries he has placed all students of analysis and of celestial mechanics in his debt.

Optics—In the field of optics he undoubtedly originated the science of spectral analysis. In the hands of Sir William Huggins, and his successors this had led to a revelation of the chemistry of the most distant stars, and to a realization of the one-ness of the whole universe.

Newton's telescope was insignificant enough to look at, but it was the forerunner of the mighty instruments that are focussed on the skies in these modern times.

Even medical men, who depend so much on the microscope, are much indebted to Newton.

Astronomy—Astronomy is known as "the exact Science". Great progress has been made since Newton's time. But he was largely responsible for the foundation on which subsequent astronomers have built. He co-ordinated the genius of those who went before, and determined the lines which those who came after should follow.

Surveyors, and sailors alike both owe something to Newton. Indeed there are few who enjoy the benefits of civilization who do not have Newton to thank for more than they may imagine. The more we learn the more we realize our indebtedness to the supreme genius of the 17th century.

Conclusion. England is justly proud to have been the birthplace of Sir Isaac Newton, and of William Shakespeare. But perhaps it is hardly correct to call these men "Englishmen". Such supreme genius—in Science, and in Literature—raises a man above mere nationality. They become world figures. They are not for an age, but for all time. They are not for a nation, but for mankind. We in Canada may be just as proud of these men as are those who were born in the land where such genius flourished.

Newton's last years were a weariness to the flesh. He was much troubled by sickness, and often suffered acute pain. But he showed much patience and fortitude. The little country lad lived to be recognized as the greatest genius of his age, to be the friend of the great and the good, and to enjoy the fellowship of Kings and Queens. His latter years were crowned with honours.

When the great Philosopher died he was laid in state in the Jerusalem Chamber, and buried in Westminster Abbey. Monuments have been erected to his memory, in London, in Cambridge, in Grantham, and elsewhere, but the greatest monument of all remains his immortal work.

Those who read Latin may appreciate his epitaph in Westminster Abbey. The translation given by Sir David Brewster is as follows:—

Here Lies
SIR ISAAC NEWTON, KNIGHT,
Who by a vigour of mind, almost supernatural,
First demonstrated
The motions and figures of the Planets,
The Paths of the Comets, and the
Tides of the Ocean.
He diligently investigated
The different refrangibilities of the Rays of Light
And the properties of the Colours to which they give rise.
An Assiduous, Sagacious, and Faithful Interpreter
Of Nature, Antiquity, and the Holy Scriptures,
He asserted in his Philosophy the Majesty of God, and
exhibited in his Conduct the simplicity of the Gospel.
Let Mortals rejoice that there has existed such and so great
An ornament of the Human Race.
Born 25 Dec., 1642; Died 20 March, 1727.

Great and majestic though these words are, I think that they lack the beauty and simplicity of Newton's own words, which might well be appended. Not long before he died the white-haired Philosopher uttered these memorable words, which shall be remembered as long as his greatest monument endures:—

> "I know not what I may appear to the world; but to myself I seem to have been only like a boy, playing on the seashore, and diverting myself in now and then finding a smoother pebble, or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

Newton's mind seems to reflect Milton's majestic line,

> "As children gathering pebbles on the shore."

I can think of no more fitting conclusion to the story of Newton's life than the last verse of Addison's famous hymn:—

> "What though in solemn silence all
> Move round the dark terrestrial ball?
> What though no real voice, nor sound,
> Amidst their radiant orbs be found?
> In Reason's ear they all rejoice,
> And utter forth a glorious voice;
> Forever singing, as they shine,
> The hand that made us is divine."

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ISAAC NEWTON*

(DECEMBER 25, 1642—MARCH 20, 1727.)

Isaac Newton has been regarded, for the last two hundred years, as the dominant figure in the history of science. His law of gravitation has been regarded as the most perfect and universal of all scientific laws, and his discovery and exposition of it as the greatest single achievement of scientific genius. He has been, in the imaginations of many very able scientific men, an almost superhuman figure. It has been said, in our time, that Newton towers above all other scientific men to an extent which is without equal in any other branch of human achievement. Such an attitude, although it may be justified, seems to have a tendency to inhibit the critical faculties. The state of perpetual ecstatic admiration does not seem to be compatible with a genuine and penetrating attempt to understand the man and his achievement. The unsatisfactory character of most of the writings on Newton is partly due to the writers' attitude towards him, perfectly natural though that attitude may be. The fact, therefore, that the whole Newtonian outlook on the universe is now being replaced by a different one may enable us, as a psychological by-product, to get this colossal figure into some sort of perspective. It is unilluminating, for instance, to be told that Newton had the "perfect scientific mind." What sort of mind is that? How does it differ from the minds of Kepler and Cavendish, those two extremes of the "scientific mind"? And what was the quality of Newton's "originality"? How far was he the product of his time? And surely we could now endure a rather more acute discussion of his character as a man. We should like to know what that simple Christian piety, so greatly approved of by Sir David Brewster, really indicates in Newton. His curious reluctance to publish his researches and his cheerful abandonment of science on being made Master of the Mint are also matters of

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great psychological interest. So great a genius and fascinating a character deserves something more than exclamation marks. It is true that adequate studies of certain aspects of Newton's achievement have appeared; but we are still without a satisfactory critical biography of what was, presumably, the greatest of scientific geniuses.

One of the most interesting problems of Newton's character is presented by his attitude towards his own genius. His scientific capacity has probably never been equalled, and yet this "High Priest of Science," as Brewster calls him, certainly never took up a priestly attitude towards his science. He had none of that passion, verging on fanaticism, for scientific discovery that has distinguished so many scientific men. With unprecedented discoveries within his grasp he would abandon an investigation for years and turn his attention to other things. It almost seems as if some of his key discoveries were the result of a transient curiosity rather than of a passionate desire to explore the secrets of the universe. Once involved, his concentration was extraordinary, but, the particular point settled, he was as likely as not to drop the whole matter until some fresh burst of curiosity or the entreaties of some unsuccessful investigator made him take it up again. In this detached, almost indifferent, attitude towards his own powers Newton is unique. It seems to be almost a matter of chance that he took up science at all. As a boy Newton was largely occupied in making mechanical models, and he also, it is said, practised drawing and tried to write poetry. Unlike most great mathematicians, he gave no evidence of mathematical precocity. When he went to Cambridge, at the age of nineteen, it was not with any definite intention of studying mathematics. He came to mathematics through picking up a book on astrology at Stourbridge Fair and finding that he could not understand a certain diagram in it without a knowledge of trigonometry. He therefore purchased an English Euclid, but found it so easy that he threw it aside "as a trifling book." He went on to Descartes's Geometry, which was difficult enough to interest him, and from this to Vieta and Wallis's Arithmetic of Infinites. The new subject interested him considerably, and early in 1665, the year in which he took his

B.A. degree, he had discovered the binomial theorem and invented the differential calculus. For part of this and the succeeding year Newton lived at home to avoid the plague; and during this time, besides developing his calculus, he made various optical experiments and thought out the fundamental principles of his theory of gravitation.

These really amazing achievements seem to have been attended with no sense of exultation. It is doubtful whether Newton was ever fully conscious of the difference between his powers and those of other men. Certainly he never betrays any sense of responsibility towards his genius. He spent a long lifetime in meditation, but chiefly because he found meditation a more agreeable way than any other of passing his time. There is no trace of the conquering young heaven-stormer about the young Newton. His secretiveness seems to be, at bottom, the outcome of indifference. The motives that are supposed to inspire great discoverers, the desire to benefit their species and add to the sum of human knowledge, are almost as little discernible in Newton as in Cavendish. Having found that his optical researches aroused controversy, he writes:—

> I see I have made myself a slave to philosophy; but, if I get rid of Mr. Lucas's business, I will resolutely bid adieu to it eternally, excepting what I do for my private satisfaction, or leave to come out after me; for I see a man must either resolve to put out nothing new, or to become a slave to defend it.

These threats to withhold his results from the world, or even to abandon science altogether, were by no means empty threats. He did withhold many of his results for several years—indeed, it is doubtful whether, but for Halley's importunity, the "Principia" would ever have been written—and even before he became Master of the Mint he was on the point of abandoning science altogether. It would hardly be too much to say that whatever he did he did for his "private satisfaction." As a young man of twenty-six, after solving, at Collins's request, some problems that had proved insoluble to other mathematicians, he insisted that the results, if published, should be published without his name appearing, "for I see not what there is desirable in public esteem, were I able to acquire and maintain it: it would perhaps increase my acquaintance, the thing which I chiefly study to decline." The aloof, self-sufficient

note here is quite unmistakable. And although he was often willing to assist other investigators, he never seems to have asked for help, nor to have invited collaboration. He regarded his contemporaries chiefly as men who might involve him in abhorrent controversies.

With no desire for "public esteem," with no sense of responsibility towards his genius, and with no feeling that he was called upon to "benefit humanity," there was not much to link Newton to his fellow-men. And, indeed, he never had an intimate friend, and there is no evidence that he ever loved a woman. His manners have been described as pleasant and even charming; but, judging from a letter he wrote while still a young man, to a Mr. Aston who was about to travel, it would be possible to assume that they were very largely diplomatic. He advises Mr. Aston, a young man of the same age as himself:

> When you come into any fresh company, 1. Observe their humours. 2. Suit your own carriage thereto, by which insinuation you will make their converse more free and open. 3. Let your discours be more in querys and doubtings than peremptory assertions or disputings, it being the designe of travellers to learne, not to teach. Besides, it will persuade your acquaintance that you have the greater esteem of them, and soe make them more ready to communicate what they know to you; whereas nothing sooner occasions disrespect and quarrels than peremptorinesse. You will find little or no advantage in seeming wiser, or much more ignorant than your company. 4. Seldom discommend any thing though never so bad, or doe it but moderately, lest you bee unexpectedly forced to an unhansom retraction. It is safer to commend any thing more than it deserves, than to discommend a thing soe much as it deserves; for commendations meet not soe often with oppositions, or, at least, are not usually soe ill resented by men that think otherwise, as discommendations; and you will insinuate into men's favour by nothing sooner than seeming to approve and commend what they like; but beware of doing it by a comparison.

The object of this kind of behaviour is to make the necessary intercourse with one's fellows as effortless as possible. These maxims are recipes for conserving energy and are proper, therefore, to the self-contained, meditative type. We can see that Newton's character admirably fitted him for the pursuit of scientific truth. He had not only greater abilities than his contemporaries, but a more "dispassionate" disposition. His most ardent rival, Robert Hooke, although often displaying an acumen scarcely inferior to that of

Newton, was rendered comparatively ineffectual by his peevish temper and inordinate love of reputation.

Together with his fortunate moral and emotional qualities Newton possessed a physical structure that could support the most intense and prolonged mental effort. His power of "paying attention," as he called it, was unprecedented. There are a number of well-known and authentic anecdotes that testify to his extraordinary power of concentration. He worked incessantly, often went without food and took very little sleep. He had no recreations or pastimes, and took no exercise. Nevertheless, he lived to the age of eighty-five. Humphrey Newton, who was his amanuensis during the time of the composition of the "Principia," states:—

> He never slept in y^e^ daytime y^t^ I ever perceived; I believe he grudged y^e^ short time he spent in eating and sleeping. . . . In a morning he seemed to be as much refreshed with his few hours' sleep as though he had taken a whole night's rest. He kept neither dog nor cat in his chamber, wh^ch^ made well for y^e^ old woman his bedmaker, she faring much y^e^ better for it, for in a morning she has sometimes found both dinner and supper scarcely tasted of, wh^ch^ y^e^ old woman has very pleasantly and mumpingly gone away with.

Only once does he seem seriously to have broken down. There is evidence that he suffered during the years 1692 and 1693 from some form of mental derangement. The "Principia" was published in 1687, so that the tremendous effort of composing that work can hardly have been responsible for the breakdown. But that the breakdown occurred is made quite clear by the very queer letters he wrote to Pepys and Locke. In the letter to Pepys he says himself that he has "neither ate nor slept well this twelvemonth, nor have my former consistency of mind." Some authorities have thought that he never fully recovered from this illness, and in that way explain his subsequent scientific inactivity. But there is no reason to suppose that Newton had lost his powers. The challenge problems submitted to him in later years by Continental mathematicians were solved with the same old easy mastery. The fact is that to Newton one kind of activity was very much as important as another, and he took his official duties as Master of the Mint very seriously. We need not suppose that the following remark, in a letter to Flamsteed, expressed a merely temporary mood: "I do not love to be printed on every occasion, much less to be dunned

and teased by foreigners about mathematical things, or to be thought by our own people to be trifling away my time about them when I should be about the King's business." This is not the only occasion on which Newton refers to mathematical pursuits in a somewhat contemptuous tone. His general outlook appears to have been extremely conventional. He was a bigoted Whig and a bigoted Churchman. In these matters he gives no evidence of a profound, sceptical and independent mind. There can be no doubt that to Newton a great dignitary of Church or State was at least as important as a great scientific man; and he doubtless valued his position as Master of the Mint at least as highly as his position as President of the Royal Society. Perhaps we have another example here of his deep-rooted unconscious instinct for self-preservation. A sceptical outlook on religious and social matters would have disturbed his exquisite adjustment as a thinking machine. His general outlook we can interpret as an unconsciously formulated protective covering. Within its shelter he was able to pursue his proper business of dispassionate meditation.

We see, then, that Newton comes very near to Nietzsche's description of the "objective man," a passionless being concerned only to "reflect" such things as he is tuned to perceive. Newton is an even more singular example of this type than Cavendish; for Cavendish was at least devoted to science, while Newton seems to have been relatively passionless even about that. All these characteristics of Newton's must be considered as advantageous for the prosecution of his life's work. They were, all of them, necessary conditions for the perfect functioning of his intellect. And that intellect, as all the world has been long agreed, was probably the finest that has yet concerned itself with science. The impression his work makes on other scientific men may be typified by Laplace's remark that the "Principia" is the supreme manifestation of human genius, and by Lagrange's remark that he felt dazed at this exhibition of the capacity of the human mind. It is Newton's combination of mathematical power, insight into physical phenomena and experimental ability that make him unique in the history of science.

Newton was about twenty-three years of age when he first surmised his law of gravitation; but he was hampered in his calcula-

tions by having assumed an incorrect value for the radius of the earth, and, as was entirely characteristic of him, he simply put the calculations on one side. Fourteen years later Hooke, at the request of the Royal Society, wrote to Newton asking if he had any contributions to send them, and received an answer that Newton had abandoned science. Newton was, as a matter of fact, devoting much of his time to theology, a subject that interested him all his life. But in his letter Hooke had mentioned Picard's new value for the radius of the earth. With these new data Newton took up his old calculations and verified, from the motion of the moon, his inverse square law. He also, having the orbits of the planets in mind, proved that, if a body describe an ellipse under the influence of a force directed to a focus, that force must vary as the inverse square of the distance. And he further proved that a body projected under the influence of such a force would describe an ellipse or, more generally, a conic. Having obtained these enormously important results, Newton appears to have satisfied his curiosity for the time being, and put his calculations away—losing them, as it subsequently appeared. Five years later, in August, 1684, Halley came to Cambridge to consult Newton about a problem. Some of the acutest intellects of the time, as Huygens, Hooke, Halley, Wren, had a suspicion that the orbits of the planets pointed to the existence of a force directed towards the sun and varying inversely as the square of the distance. But, in spite of repeated attempts, they could not solve the mathematical problem involved. Wren, Hooke and Halley discussed the problem together; and Hooke, as was characteristic of him, professed to be able to solve it. In spite of the offer of a prize from Wren, however, he never produced the solution, and did not convince the others that he could. This was the state of affairs when Halley came to Newton and, without mentioning the speculations of Hooke, Wren and himself, asked Newton what orbit a body would describe under the action of the inverse square force. Newton immediately answered, *an ellipse*. "Struck with joy and amazement," Halley asked how he knew it; and then Newton, in looking for the calculation, found he had lost it. He promised, however, to repeat the calculation and to send it on. On receiving the demonstration Halley went again to Cam-

bridge. In the meantime the conversation with Halley had aroused Newton's interest in the matter, with the result that before the autumn he had worked out many of the fundamental propositions of the "Principia." When Halley saw these new results he fully realized their immense importance, and prevailed upon Newton not only to send them to the Royal Society but really to devote himself to working out the consequences of his theory of gravitation. Thereupon, by an almost incredible intellectual effort, Newton composed the first book of the "Principia" by the summer of 1685. This feat has been called the greatest single illustration of Newton's powers, and it sets a standard of achievement for all time. By the summer of the next year the second book was completed and the third begun. But Hooke's sleepless jealousy had been aroused by the communication of the first book, and he claimed to have preceded Newton in the discovery of the inverse square law. Newton dealt with his claims in some detail and then, after mentioning that he had designed the whole work to consist of three books, made the alarming statement:—

> The third I now design to suppress. Philosophy is such an impertinently litigious lady, that a man had as good be engaged in lawsuits, as have to do with her. I found it so formerly, and now I am no sooner come near her again, but she gives me warning.

Halley, who, to the great discredit of the Royal Society, had been left to bear the whole cost of printing and publishing the work, wrote an imploring letter to Newton and informed him that the Royal Society disallowed Hooke's claim. Satisfied on this point, Newton went on with the book, and added the almost unnecessarily handsome note, "The inverse law of gravity holds in all the celestial motions, as was discovered also independently by my countrymen Wren, Hooke, and Halley." The complete work, entitled "Philosophiæ Naturalis Principia Mathematica," was published about midsummer of 1687. It made a great impression throughout Europe, and the whole edition was quickly sold.

It is the principles enunciated in this work that have dominated scientific thought for over two hundred years. Newton's other achievements are less important. His experimental work on light was of great value; but his corpuscular theory of light, although perhaps destined to a partial rehabilitation, proved itself much less

satisfactory than the undulatory theory. Amongst his purely mathematical achievements, the differential calculus, as it left his hands, suffered from an inconvenient notation. Although Newton was unquestionably the first inventor of this calculus, it is in the form given to it by Leibniz that it has proved best adapted to development. The spasmodic quality that we have noticed in following the history of the "Principia" is characteristic of much of Newton's scientific work. He would neglect the studies for which he was so superbly equipped in order to devote his time to theology and alchemy. He wrote on the prophetic books of the Bible, and devoted much study to the writings of Jacob Boehme. At one time he spent several months searching for the philosopher's stone. It is evident that Newton was credulous to an unexpected degree. He gives evidence of having possessed a strong vein of somewhat inferior mysticism. This has not been unusual with mathematicians, and it is only rarely that it rises, as in the case of Pascal, to a degree of insight that leads to real achievement. It is probable, therefore, that Newton's religious preoccupation arose partly from his love of abstract speculation and partly because it furnished an outlet for his mystical impulses. There is no reason to suppose that he had any real religious fervour, or that his piety was much more than passionless decorum.

The perfect "purity," as it were, of Newton's scientific mind is strikingly illustrated by his conception of the *rôle* of the scientific hypothesis. "Hypotheses non fingo," he said on one occasion after being bitterly attacked by the followers of Descartes. But the word "hypothesis" here has not its meaning in modern science. The hypotheses to which Newton objected were of two kinds, metaphysical and physical. Descartes based the laws of nature upon certain axioms which he considered to be necessary truths. Newton insisted that all theories must be based upon the observation of phenomena, and consist in deductions from the phenomena. And he objected to his contemporaries' predilection for filling space with all kinds of aethers and fluids for which there was no evidence. His own theory of gravitation was not, in his mind, an hypothesis. He did not present it as explaining the mutual attraction of bodies for one another. He did not see that he was

required to give such an explanation. What he had given was a mathematical description of the way bodies actually behaved. He did not profess to say *why* they behaved in that way. As a matter of fact he did not think that science could give an answer to that question, since he thought gravitational action due to the direct activity of God. The Cartesians made the laws of nature embodiments, as it were, of *a priori* mathematical principles: that we could not verify them exactly was due to the imperfections of our instruments. Newton thought that all mathematical formulations of the laws of nature were probably imperfect. He believed that immutable and objective laws existed; but he believed that their mathematical formulation, even his own law of gravitation, would have to be modified as science progressed. The whole of this outlook, that seems so natural to us, was so peculiar to Newton that none of his contemporaries understood it. Nothing better illustrates his scientific quality than the fact that what is now regarded as the only correct scientific outlook should have been grasped by him alone.

Newton's dynamical system, which was until recently almost axiomatic in the minds of scientific men, resulted from the crystallization of the more or less confused ideas of his predecessors. Newton's first two laws of motion, for instance, and possibly also the third, can be deduced from Galileo's work; but they are nowhere enunciated distinctly. Newton's formulation and perfectly clear understanding of his dynamical system was a really very considerable feat—how considerable is shown by the fact that, twenty years after the publication of the "Principia," even Leibniz still had confused ideas on the subject. Newton was capable of overlooking a possibility, as when he thought the construction of an achromatic telescope impossible, but no one ever lived whose mind was less confused. This quality of perfect clarity which enabled him to formulate his laws and to seize the essentials of any problem, combined with the tremendous mathematical virtuosity that enabled him to apply his theorems so triumphantly, justified the contemporary opinion of him as "the lawgiver of the universe." The same quality made him dissatisfied with his early formulation of the calculus and, at a time when Leibniz remained content with "In-

finitesimals," there is evidence that Newton was working towards the subtle modern notion of the "limit." He was also one of the very few mathematicians of his time, and indeed, of the next hundred years, who realized that infinite series should be convergent.

The fundamental assumption of the Newtonian dynamics is the existence of one universal time system. He also assumed "absolute" space, but it is doubtful whether this assumption is really required by his system. The successful attack, by relativity theory, on the assumption of a universal time system has led to the creation of a new theory of gravitation and also makes the Newtonian law ambiguous. What Newton thought might possibly happen has happened. His law of gravitation has been replaced by a closer approximation. But Newton's law remains so close an approximation that it will doubtless continue to be used by astronomers for many years to come. The present condition of the scientific universe is somewhat chaotic. Everywhere there are difficulties, and one ingenious theory replaces another in the attempt to solve them. At the present time there is no one clear vantage point from which the whole of physical science may be surveyed. Our most inclusive theories cover a part only of the phenomena that have to be ordered. When Newton's work appeared men were persuaded that the key to the universe had been found, that this one man had made it possible for them to account for all phenomena and to banish all mysteries. We now know that this hope was illusory; and we may well doubt, from the standpoint of our greater knowledge and our disillusionment, whether another man will ever appear who shall occupy in the minds of men the position once held by Isaac Newton.

THE RELATION OF THE SURVEYOR TO EARTHQUAKES

By Ernest A. Hodgson[1]

HEAVEN sends us friends. We should, however, exercise considerable care in choosing our relations. The career of many a young man has been made or marred by his choice of an uncle, for example. My mission this afternoon is to introduce to you as surveyors, a certain relation of yours, the science of earthquake study, or seismology. I trust I may be able to present him in such an attractive light that you will be glad to acknowledge the relationship and that both parties to the introduction may profit therefrom.

In order to discover some of the more interesting points about this relationship, we shall have to go a long way back in history; back and still farther back, long before Eve made a monkey of a man, or Evolution made men of monkeys. History of so distant a time is, of necessity, vague. Authorities differ. Our needs will be met, if we but compile a single connected series of selected hypotheses, which will serve to account for the creation and evolution of the world, according to the facts presented. The dogmatic presentation of these hypotheses is necessary for our purpose. It must not be construed as an assertion of their absolute verity. "Speculation", says Daly, "is neither science or knowledge. Speculation of the happiest kind can do no more than point the way to possible future knowledge."

Will our speculation result in a knowledge that is practical, or one that is theoretical? Millions of words and gallons of ink have been expended in an endeavour to define the boundary between these two territories, but it has proved an even greater task than that performed by those surveyors, of whom it has been said that they are engaged in placing boundary monuments in "inaccessible positions." And the boundary is less in need of delimitation, for there is complete reciprocity in this case. So then, in presenting

[1]Presented before the Association of Dominion Land Surveyors, February 2, 1927.

those features of the science of seismology which should attract you, as surveyors, I shall not pause to make flesh of one and fowl of another: all the practical interests are scientific, and all the scientific appeals are practical.

A consideration of the world to-day reveals the fact that it is asymmetrical, or lacking in symmetry, in so far as the surface features are concerned. We can divide it (by a great circle through San Francisco, Buenos Aires and Canton) into two hemispheres, one largely covered by water, the other by land. If we examine the water hemisphere we find the land encroaching somewhat on its edges. An examination of the land hemisphere reveals great patches of water within it—notably the Atlantic, Arctic, Antarctic and Indian oceans. Considering this land hemisphere still further we are struck by the fact that if we could push the continents together we could fit the western coasts of Europe and Africa into the eastern coast of the Americas, and that Australia would fit rather well into the Indian Ocean. If we could thus consolidate the land we should be able to withdraw the edges of Asia and of the Americas from the water hemisphere. Our only ocean would then be the Pacific; our only continent a geographical League of Nations. This would be rather hard on the Atlantic Shipping Interests, but think of the grand opportunity for the railways.

A land hemisphere, one great continent; and a water hemisphere, one great ocean, may have been the condition of affairs in the early history of this globe. We shall not present the theories which attempt to account for this lack of symmetry in surface features. (Perhaps our moon was formed from the material taken from the abyss of the Pacific.) Let us imagine that such a Quaker-like arrangement of the land and water did exist at one time. Our first question is; how long ago?

To answer this we must first obtain an estimate of the age of the earth. We ask the consensus of opinion of the geologist, the astronomer and the geophysicist. These gentlemen, like most of those who deal in millions, speak with large gestures. A group of them sitting in conference for the settlement of this question are inclined to be generous. One is satisfied if they give him eight million years; another rises to remark that he must have at least ten millions. Her request is granted without debate, which nerves

a third to say that the work of his branch could not possibly have been completed in less than a hundred million. Finally, with all the generosity of a municipal council striking a tax rate, they decide to make it an even three hundred million—to take care of any unforeseen demands.

But, simply because they do not seem to care to deal with small change, we must not infer that there is any lack of sense in their budget. Changing the simile a little, they are like a man ordering a dinner for which he is to pay in German paper marks—at someone else's expense. Why make a fuss when an extra pat of butter raises the bill another hundred thousand? The total doesn't mean very much. When the bill is presented, however, the *relative* value of the items is as well determined as though the meal cost a dollar instead of ten million marks or so. In the same way, the estimate of 300 million years may be out, on the whole, by a year or two—or even more—but the *relative* lengths of the geologic eras are fairly well determined.

A smaller time scale will be convenient for present purposes. It is now about three o'clock. Let us adopt the scale of ten million years to an hour, and place the creation of the world at about nine o'clock yesterday morning. On this reckoning the single continent was differentiated from the single ocean during the early morning hours of to-day. By about six o'clock the surface began to undergo a series of changes with which we are now concerned.

During the time intervening between its creation at nine yesterday morning and the time we now consider at about sunrise to-day, the interior of the earth was probably sorting itself out into concentric spheres of varying density, the heavier materials lying nearer the centre. The lack of symmetry in its interior was slowly being eliminated. Granitic rocks, such as form the bulk of continental structure to-day, are the lightest known. These formed the surface crust of the single continent. This crustal area floated in a substratum of hot lava or basalt of greater density. It floated, partly submerged, as does an iceberg or a solid ice floe.

The former rapid cooling at the earth's surface was greatly checked by the formation of this non-conducting crust. The tidal effects were comparatively severe. Moreover, due to the rotation of the earth and to the asymmetry of the interior, a bulge formed

at each of the poles, with mid-latitude depressions separating these polar bulges from an equatorial bulge. All this time the elements were at work. Winds, chemical action, rains and rivers, all worked their will on the face of this young continent; and this erosion had its cumulative effects.

As the mid-latitude depressions began to fill with sediments from the erosion of the surrounding parts of the ancient land hemisphere, these geosynclines as they are called began to deepen because of the accumulated mass. This exerted a tension on the higher portions of the continental area. Thus began a crumpling in mid-latitudes north of the equator. The crustal material began to pile up and raft together. A thick, and ever thickening band developed along the geosynclines. These bands sank deeper into the basalt. They became gradually warmed, very slowly for the rocks are poor conductors of heat. As they warmed their density became less and the bands were gradually elevated, floating higher in the basalt and forming mountain ranges.

We must not forget that our present continents, the two Americas, Europe, Asia, Africa, and Australia, were then all in one, occupying about half the area of the globe. The mountain ranges then formed still appear, part in America (the Appalachians), part in Europe and Asia. Daly says, "The mountain mass extended from west of Arkansas, through Alabama, New England, Newfoundland, Britain and France, Germany, Russia, and all across Asia to China. It was a colossal, probably uninterrupted chain of mountains all the way." These deductions are supported by a study of the formations of each. The fossils show the presence of similar forms at corresponding positions. In structure, composition and date of formation they are found to correspond. A similar correspondence of mountain chains, in continents now widely separated in the south mid-latitudes, which is explained in the same way as above, is found between the rock structures of South Africa and those of Argentina. Referring again to our time-scale, these mid-latitude mountain chains were undergoing their elevation at about noon to-day. Let us look back for a moment and see what other vicissitudes were suffered by the continental area during the course of the morning.

A study of the geological features of the world reveals the fact

that the continental area suffered repeated slight elevations and depressions. The depressions are marked by the deposition of sediments in the former shallow seas. The elevations are shown by erosion. One of the powerful erosive agents was ice. There have been great ice sheets at various periods in the earth's history and over various sections of the continental area. We consider now only the very ancient ones—that came and went in the early morning hours of our time scale. They scored the rocks over which they slowly made their way. Some of these glaciated surfaces are evidently of the same geological period, though occurring in what are now widely separated places. Geologists tell us that it was probably the same great ice sheet that glaciated the ancient rocks of South Africa and of South America, when these were still part of the same land area—the former "basement complex"—the original "continental shield".

Parts of it are to be seen to-day. One section forms the northeastern part of Canada and Greenland—the Canadian shield, as it is called, another forms the Russian shield, and still others the Siberian, African, Brazilian, Australian, and Antarctic shields, respectively. The rocks of these shields present the evidences of their early adventures, their depressions below the level of the sea, their elevations into mountains.

If we accept the foregoing explanation of the origin of our mountains we see why sedimentary rocks are found high on their slopes. They were deposited in the crumpling geosynclines, and, after countless ages, raised to their present lofty heights, carrying with them their evidences of sea deposits in the form of fossils embedded in them. This explains the presence of sea shells on high mountains. This was a first argument against the idea of the "everlasting hills." It was objected to by a certain class of arm-chair philosophers who would limit the revelation of God to the authorized opinions of men. They are against all observation. Their recent persecution of Mr. Scopes of Tennessee is characteristic of them. They are against all scopes, including microscopes and telescopes. Alas, they, and we, must finally bow to the verdict of the stethescope.

The ancient continental shield, after ages of vicissitude was to suffer a still more drastic deformation however. The erosion

of the continental area had resulted finally in the accumulation of great masses of sediments all about its edges. These would further depress the border bounding sea and land. The semi-mobile basalt sub-stratum would flow back underneath the shield, tending still more to elevate it. A horizontal stress would develop across the shield. On our scale of time we reach a point about noon to-day—say some thirty million years ago in fact.

The horizontal tension became greater than the strength of the forty-mile thickness of granitic rocks could sustain. The continent finally ruptured along a line which is now marked by a ridge throughout the length of the mid-Atlantic. The Americas began to anticipate the advice of Horace Greely—they went west. They let the rest of the world go by; and the rest of the world also began to slide down hill toward the east. Both sections were slipping into the Pacific ocean, but into opposite sides of it. We must not think of this "landslide" as having taken place at a rapid rate. It was rather a slow creep, the sort of motion one sees in the progress of a glacier.

The crust was depressed along the nose of these movements. Sediments gathered there at increasingly rapid rates. Finally the floor beneath the ocean broke and the crustal sediments and the ancient basement complex began to pile up like floes on the nose of a flood in a river. As they increased in thickness they sank. All was below the ocean floor at first.

The process may still be going on. This last summer a world-wide endeavour was made to determine whether the continents are still drifting. The drift may be of the order of a meter a year. If so, we should be able to detect it by the determination of longitudes by wireless, very carefully conducted to-day, and repeated after the lapse of a few years. Canada has had a share in the first series of observations. The representatives from the Dominion Observatory established a station in British Columbia and another at the Observatory itself. The long series of initial observations, extending over several weeks, were but recently completed.

As the separation increased between the Americas and the other continents water poured in from the Pacific forming the Atlantic. The floor of this ocean was so thin that it broke in places and we have, as a result, volcanic islands in mid-Atlantic.

Presumably, too, basalt flowed up in the depression, and formed, on freezing, the floor of the new-born ocean. These regions are still subjected to earthquakes. A great quake occurred in one group, the Azores, on August 31, 1926, killing nine persons and injuring about 200. From ten to fifteen per cent of the houses in the town of Horta will have to be demolished.

But think of the great earthquakes there must have been in the van of this great emigration. And reflect on the abyssal deeps which would be formed as the pressure continued. Then consider the fact that earthquakes occur all about the Pacific margin even to-day and that ocean depths at places exceed five miles. Remember too, that in the Aleutian Islands, for example, the mountains are still below the sea, and may still be rising.

Careful geodetic measurements made in California, seem to indicate that part of the mountains there is being thrust up over the rest at a measurable rate. Cities are now built on part of the moving mass. From time to time the movement is held up by friction. Its release is marked by an earthquake. A concerted effort by the seismologists of California, in co-operation with the United States Coast and Geodetic Survey, the various Topographical Surveys operating in the State of California, the United States Geological Survey, and the California Institute of Technology, has been organized under the direction of a Committee of the Carnegie Institution of Washington, to determine the laws of these movements and to learn the best means of protecting life and property there. You will see that these conditions are very different from those we have in the seismic region of Quebec.

To understand the situation in Quebec we must consider another geological event, which, according to our time scale, occurred only a small fraction of an hour ago. At that time a great ice sheet covered most of Canada. We shall confine our attention to that portion of it that lay on Quebec and New England. The sheet was very thick—from 3,000 to 6,000 feet. This great weight on a crust but some forty miles thick and supported by a potentially mobile basalt, caused a downwarping of a considerable area. That the province of Quebec and eastern Ontario were so downwarped can be readily shown. Old sea beaches formed as the ice melted away. These are found at points now 600 feet and

more above sea level. You can find sea shells in the sand, just east of the city of Montreal and also behind the city of Quebec. An old sea beach is visible near Grand Mere, over twenty miles north of Three Rivers.

Without going too greatly into details we may say that this downwarping of the ice has been followed by an upwarping on its removal. Is it still in progress? If so it may be either a slow rise (of which we shall speak presently) or it may be taking place in a series of jerks—earthquakes. On February 28, 1925, an earthquake occurred at a point about 90 miles below Quebec, which caused considerable damage at its epicentre and which was sensibly felt (without instruments) as far west as the Mississippi and as far south as Virginia. A sensitive seismograph in Belgium recorded the tremors for over five hours with a maximum amplitude on the record of over three inches. If this earthquake were due to the intermittent rising of the area depressed by the ice sheet, we would expect that precise levelling would show traces of it if the work were re-done.

The only line of precise levelling traversing the area was that run in 1915 along what was then the Intercolonial Railway from Rivière du Loup to Levis. This line was re-run in 1925, through the kind co-operation of the Geodetic Survey. It is true that the differences found were of the order of the probable errors, but they were systematic and showed an upwarping of the east end with respect to the west, a finding confirming the other field work done by the seismologists. This lends weight to the deduction that the earthquake occurred along a fault crossing the St. Lawrence near Riviere Ouelle, and that the sea-ward side of the fault snapped up, with respect to the land-ward side.

In this area then, precise levels and geodetic triangulation are extremely important controls which should be carried on with great care and as soon as possible, so that after another earthquake, suspected areas may again be worked over. This is one phase of the interest of surveyors in this region.

Before mentioning any others let us take a few moments to examine the instrumental side of seismology. We shall pass over the instruments with the brief explanation that these are of two general types, registering respectively horizontal and vertical

components of the fluctuations of the pier on which they are mounted. Using two of the horizontal type and one of the vertical we obtain an automatic resolution of the complex movements of the pier in space, into three records of the component motions in three planes mutually at right angles. Let us examine the possibilities of a study of these under three conditions; first where the distance about the surface of the earth, from the station to the epicentre of the earthquake (referred to as Δ) is more than 500 and less than 10,000 km., second where Δ is over 10,000 km. and lastly where Δ is less than 500 km.

In the first case we can determine quite accurately the value of Δ and also the time at the origin when the shock occurred. This latter is designated by the symbol O. For a sharply defined earthquake the value of O is surprisingly consistent though obtained from the records of stations situated in various directions from the epicentre and at different distances therefrom. Moreover, records of the same earthquake, obtained at widely separated stations with similar instruments are notably alike in character and give the seismologist a feeling of confidence in the performance of his instruments, the comparatively homogeneous character of the earth, and the general accuracy of his tables. Where the initial phase is well marked, the azimuth can also be determined from the three records obtained at one station. The records of the St. Lawrence earthquake were read within a couple of hours after the shock. Before midnight C.N.R.O. broadcast our announcement that the epicentre was "near the mouth of the Saguenay."

For distances greater than 10,000 km. the earthquake waves reaching a station are interfered with by the dense metallic core of the earth. A study of the records at stations sufficiently removed from the epicentres of large earthquakes is yielding much information as to the conditions within the earth. Ottawa is particularly well situated for such work, with respect to the many earthquakes of the Pacific islands and the East Indies.

For distances within 500 km. or thereabouts another possibility appears. If we can get a fairly regular sequence of well defined but not very heavy shocks we can arrange to study the crust of the earth at that place by means of the earthquake waves reflected

at its lower surface where it meets the basaltic layer. In Quebec we have many such—we know there are at least ten a year. When the sensitive seismographs are in place we may find there are as many as a hundred. At present we do not know. From time to time relatively severe shocks occur. The one previous to that of February 28, 1925, occurred about 11 a.m., October 20, 1870 It was quite comparable with the one of two years ago. It was sensibly felt in New York City. How soon the next will happen no one can say. We have plenty of time to study the conditions if the interval should again be 55 years or thereabouts. In the section between the St. Lawrence and Saguenay rivers and adjacent parts we have fairly regular earthquakes which would collaborate with us in such a study.

For a complete investigation we would require special vaults, arranged at the points of a triangle covering the area to be studied, say one near Quebec, one near Chicoutimi, and a third near Rivière du Loup. In these we require installations of special type seismographs, three components in each vault. We drive the recording drums of all nine seismographs by means of synchronous motors, run by the same power source, and mark the time by impulses from one master clock. With such a set up we could very soon determine the position of the epicentres within a mile or so. Let us consider one such epicentre as determined and note the work which might profitably be done by the surveyor.

The geodetic survey could run branch lines of levels into the area and spread their triangulation net over it; the topographical survey could then prepare maps of the area showing the relief. The geological survey could examine the limited region thoroughly. We would thus have precise controls. We could study the seismic movements by means of the seismographs. But when next this particular spot was disturbed the surveyor would alone be able to tell us whether it had risen or fallen or the direction of horizontal shift.

At present no such complete installation has been made, nor is it in immediate prospect. But through the co-operation of the commercial interests in the province two instruments are being installed in specially constructed vaults. The vault sites have been covered by the triangulation nets of the Geodetic

Survey. Topographic maps are being prepared. The vaults are completed and the instruments are about to be tested. When they are installed we shall be able to determine *definitely* the number and relative intensity of the local tremors, and *rather indefinitely* the centres affected. We shall, however, be able to measure the seismicity of the vault sites. If they prove to be the centres or near the centres of slight seismic activity, the co-operation of the surveyor will again be required to determine what the movement has been since the control observations were made. The investigations will serve to show the possibilities of a complete installation. The conditions in Quebec are not those of California by any means, but if the seismic centres there are determined, it will be the essence of good judgment to avoid them as sites for commercial enterprises which form so large a part of the present or potential wealth of the province.

In Quebec then we are studying the problem of a presumably rising area. It has risen in the past, for deep sedimentary deposits are there which have been laid down when the sea covered it. Many of these deposits are unstable when wet. In the past serious landslides have occurred in them. On April 6, 1908, a landslide on the Lièvre River at Notre Dame de la Salette, moved a bank over 1,300 feet long and 60 feet high with an average width of 400 feet from its original position clear across the river. It slid bodily, without warning, into the river, resulting in the death of 33 people, and the destruction of fifteen houses, twenty-five outbuildings and six acres of good farm land. Such landslides have been reported since that time, at other points. Serious ones have happened within the past two or three years, but without loss of life. A study of these landslides comes within the purview of seismology. They may be set off quite readily, in damp weather, by a most moderate earthquake, and they may result in very serious damage. Where evidences of these are noted by the surveyor in his work, he would be assisting the cause of seismology by reporting them.

One more point before we leave the east. A commission has been recently appointed by the United States, National Research Council, to study the shore line of the United States, bordering the Atlantic. Is this shore rising or falling or stationary? Those

surveyors who are sent far north in Canada, or by ship to Labrador or Greenland and other northern places would assist greatly by keeping notes of any evidences of elevation or depression of shore lines, taking photographs where possible. Preferably those who are going into these areas might read one or two books dealing with shore line movements. Also, if any mention is made of earthquake tremors in these northern latitudes we should like to know about them. An effort is being made to get seismographs into the far north, or near the edge of the retreating ice cap. Denmark has announced her intention of establishing a station at Jan Mayen island, lying between Greenland, Iceland, and Norway. Mr. J. J. Shaw of England has sent one of his seismographs to be set up in Greenland by a Danish scientist. The seismologists of the United States are agitating for the establishment of a seismographic station on one of the Aleutian islands. As yet no operating station has been established and reported on its findings. Any information the surveyors happen to run across in their work would be valued by those working on this disputed but important problem. It is not likely to affect us in our generation to any marked extent, but if the coast *is* rising we would do well to establish harbours where dredging would not be a too important factor in the future. Whether such consideration should apply to the vexed question of the location of a Hudson Bay harbour one cannot say. We don't know whether this region is rising or not. It may not be, but, on the other hand, if our hypotheses are correct, it may be rising rather rapidly.

In conclusion, let us look at the conditions on our Pacific coast. We recall the hypothesis that the continent is drifting toward the Pacific, an area of stress and strain marking its western coast line. Deep ocean floors, many earthquakes, and volcanoes mark most of the Pacific shores. There are so many volcanoes that we speak of the Pacific Ring of Fire. What are volcanoes? Have we any in Canada?

Briefly, a volcano is a fault or abyssal crack through the crust of the earth, which permits the lava of the basaltic layer to rise within it, and under certain circumstances to overflow at the surface or to explode. It has been noted that the continent floats in the basalt, partially submerged, like an iceberg. We would not

then expect the lava to come out unless some definite forces act. Pressures of the drifting continents may furnish such a force but the most probable one is called "gas fluxing".

When the crust formed, it prevented the escape of gases from the basalt. Much was dissolved in it. When the basalt rises in one of these abyssal faults the pressure at its surface is lessened. Gas is thus released from the basalt. It is very hot, and results in a heating of the top of the column. This expands the column of lava until finally it overflows. Then, the gas being exhausted for the time being, it is unable to rise above the surface and freezes over. If it were not for fresh supplies of heat from below, the basalt would freeze over in the vent forming a plug to a depth of several hundred feet in a single day. The frozen surface formed when the gas had ceased to be given off, prevents the escape of that gas which finally makes its way to the vent from below. The pressure increases because of the gas and the local heat tends to melt the plug. When the critical point is reached the weakened plug is blown out, carrying an onrush of lava with it—the volcano is again in eruption. The cycle repeats itself many times.

This continues until the supply of gas in the magma chamber gives out, the basalt giving up all its dissolved gases. The hot air having been expended, the volcano becomes silent, cold, and dark—like the Auditorium after a political meeting.

Although, the plug freezes to a great depth in the vent of an extinct volcano, the basalt forming it is porous. If the crater stands full of water for a long time the moisture may penetrate down to the hot lava below. When this occurs steam forms and when the pressure is great enough an explosion occurs. In 1888, the extinct volcano of Japan called Bandai-San, was looked upon as a simple mountain. A priest climbed this 3,000 foot elevation one day and had his meditations rudely interrupted by a tremendous explosion, caused by the steam formed from the percolated water. A section of the mountain 2,000 feet high and some four square miles in area blew up before his eyes. He lived through his experiences because the explosion was due to steam alone. Had it been an explosion of magmatic gases he would have been asphyxiated even had he been fortunate enough to escape the projectiles. Explosions of the same kind occurred in 1924 in Hawaii.

Now, have we volcanoes in Canada? Yes, many of them. But they are nearly all extinct. Montreal mountain is an extinct volcano. Even our friend the priest of Japan, would accept the verdict that it isn't loaded. It is not quite the same thing in British Columbia. The following facts were obtained from the surveyors who worked on the International Boundary between Alaska and British Columbia.

At a point about a hundred and fifty miles due north of Prince Rupert, near the head waters of a tributary of the Unuk river which flows into Behm canal, is an old crater. Many centuries ago it was in eruption for the lava flowed down two sides, forming canyons on one branch of the Unuk and filling the channel of a second tributary. This lava lay there long enough that large trees grew on it. Then at a much later date—probably of the order of a hundred years ago or less—another eruption took place. This time the lava flowed only into the tributary whose channel had been filled by the previous flow. The smaller vegetation growing on the old flow was burned at once. The larger trees were killed remaining long enough to leave pot holes in the lava where they stood while they were being burned off below the surface. Then they fell over on the lava bed. And there they are to-day. The situation is an ideal one for the decay of timber—the climate is moist and warm. The deduction is inevitable that the last flow was not very long ago—in geologic time at any rate.

This is an interesting and important fact. What was the elapsed time between the first and second eruptions? May we expect another? The crater is filled with ice and snow, the climate is very moist. Will the volcano ever blow up as did Bandai-San? What effect will the tremors have (if this ever takes place) on the coast cities.

Had it not been for the observations and reports of the officers of the Boundary Commissions it is doubtful whether we should ever have had anything like as good an account as we now possess, for years to come. People do not go up there very often. In 1909 a survey party went up to set a monument on the boundary. Fearing to be trapped by an impending storm they left, closing the season without setting the monument. They returned next in 1920. So confident were they that their tools would not be

disturbed on the boundary line, after a lapse of eleven years, that they simply took some cement and went up to the station. There was the monument as they left it. Their tools were undisturbed. (There isn't a garage mechanic within two hundred miles). This is an added example of the opportunities surveyors have to contribute important data to seismology if they are sufficiently interested in its problems for the facts to impress them.

So then, I have given you an extended introduction to your new relation; for seismology is a new relation to surveyors in Canada. I have traced his lineage into the dim and distant past and expatiated at length upon his future. In other countries he may be looked at askance, but in Canada he is not likely to get you into any serious trouble and he is likely to prove an interesting and profitable relation to claim and to cultivate by means of both systematic and incidental opportunities as these may present themselves.

Dominion Observatory,
Ottawa, Canada,
January 29, 1927.

THE LUNAR ECLIPSES OF 1927

By Willard J. Fisher

THERE are to be two lunar eclipses in 1927, both total, about the middle and end of the year. Some of their relations to the earth's atmosphere are as follows:

The first eclipse, 1927 June 15, is at its height (mid-eclipse) at 8 h 24.2 m, Universal Time, but the moon hardly gets within the umbra on the north side of the earth's shadow. The radius of the geometrical umbra is 40′.8; the outer limb of the moon at mid-eclipse is distant 40′.7 from mid-shadow. At this moment the edge of the shadow nearest to the moon's limb is cast by the earth's surface and atmosphere at about W 97°.3, N 63°.75, in the neighborhood of Baker Lake, which drains into Chesterfield Inlet, on the west shore of Hudson Bay. It would be interesting to know the weather, cloud and sky conditions in this region at this moment. But the atlas indicates hardly any population there.

In the eclipse of 1892 ,November 4, the outer limb of the moon was 43′.0 from mid-shadow, the radius of the geometrical umbra was 45′.4, so that the immersion was deeper than in the present case. But Gale, at Sydney, N.S.W., reported the limb so bright as to give the impression that the eclipse was not total; Russell, also at Sydney, said definitely that it was not total; Doberck, at Hong Kong, remarked on the brilliancy of the immersed limb. We may expect this time an opportunity to observe the density of the earth's shadow very near to the edge, but due to weather and climate conditions very different from those which ruled in 1892. Then the grazing point was over water, between Iceland and Norway, north of the Shetland Islands.

The last rays on the moon's limb at first contact with the umbra graze the earth's surface or atmosphere about W 174°.7, N 32°.7. This is sunset on the open Pacific, north of Pearl and Hermes. The rays at last contact in like manner graze about W 69°.1, N 17°.6, a point at sunrise in the Caribbean Sea, considerably south of Catalina Island, south of Santo Domingo. Observations of weather, cloud and sky at these points are desired, for

comparison with direct observations of the shadow edge at these moments.

The two internal contacts at this eclipse come so close together that they are hardly separable from mid-eclipse. At mid-eclipse the sunrise-sunset line, centered about the sub-solar point at E 54°.0, N 23°.3, passes by Cape St. Roque, Nova Scotia, Great Bear Lake, New Guinea, Gulf of Carpentaria and Enderby Land. Of all this great circle, however, only a fraction, perhaps 35°, on the two sides of the Baker Lake region, is effective in illuminating the eclipsed moon.

The second lunar eclipse, on December 8, with middle at 17 h 34.6 m, Universal Time, is of much deeper immersion, 11′ or more at most, in the southern half of the shadow. The inner (north) limb of the moon just covers the middle of the shadow. The grazing light at the contacts comes from regions about the points indicated:—

First Contact: E 41°.6, S 25°.7, in the Mozambique Channel, between Tullear and Europa Island, at sunset.

Second Contact: E 51°.0, S 51°.3, in the Sea Tang, south of the Crozets, at sunset.

Third Contact: E 164°.4, S 22°.0, southwest of New Caledonia, at sunrise.

Fourth Contact: E 157°.0, S 3°.5, northeast of Bougainville Island, at sunrise.

Observations of weather, cloud and sky at these points are desired, for comparison with observations of the shadow edge at the contacts.

At mid-eclipse the sunrise-sunset line is centered about the sub-solar point at W 85°.75, S 22°.7, and passes over or near Kaiser Wilhelm Land, Fiji Islands, Sitka, Baffin Land, Cape Farewell, Timbuctoo, Mossamedes, Cape Town. The whole southern half of this great circle is effective in illuminating the eclipsed moon at this moment.

The mere naming of the grazing points above indicates that observations within a few degrees of them are unlikely to be obtained. Still, it is desired that persons near any such, at sea or ashore, report their observations of weather, cloud and sky, at the sunrise or sunset moments indicated, either to some scientific journal or to the address, Lunar Eclipses, Harvard College Observatory, Cambridge, Mass., U.S.A.

REVIEW OF PUBLICATIONS

Constitution et Evolution de l'Univers, par A. Veronnet, Astronome à l'Observatoire de Strasbourg, chargé de conférence à l'Université. 480 pages, 4½ × 7, 29 figures, 28 frs. Paris, G. Doin et Cie., 1927.

This is another volume of the Encyclopédie Scientifique, the astronomical section of which is under the direction of J. Mascart, Director of the Lyons Observatory.

There are twelve chapters in this book, bearing the following titles:—

I. The figures of equilibrium of a mass of homogeneous liquid in rotation. Cosmogonic consequences.

II. Study of a heterogeneous mass in rotation. Figure of the earth and of the planets.

III. Physical equilibrium of a gaseous star. Gases perfect and actual. Case of a uniform temperature.

IV. Physical equilibrium of a gaseous star. Case of uniform density. Maximum possible temperature.

V. Physical equilibrium and extension of the atmosphere of a gaseous star. Comets. Giant stars.

VI. Maintenance of the heat of the sun. Age of the sun and the earth.

VII. Evolution of the sun and the stars. Correlative evolution of the earth.

VIII. Study of the condensation and the formation of the stars in an indefinite nebula.

IX. Determination of the temperature and formation of the stars. Relation between the time and the temperature of formation.

X. Study of the formation and the evolution of stellar systems, star clusters, new stars, giant stars, spiral nebulae.

XI. Formation of planetary systems. Deviation produced by neighbouring stars. Effect of the resistance of the medium.

XII. Critical study of modern hypotheses of cosmogony.

There are three distinct periods in considering the evolution and formation of the universe. To the ancients the earth was the centre, the sun, moon and stars only accessories. Next the sun was considered the centre, with the planets revolving about it. A single separate system like this could not explain the rotations and revolutions of its constituent bodies. Such were simply assumed as given.

During the last fifty years our horizon has been widened, and we have endeavoured to include the Milky Way and the star clusters. The author tries to submit to calculation the general problem of the formation of the stars. He concludes that if one assumes the matter forming the stars to be dispersed throughout space, it will concentrate into meteorites, then into stars and suns and finally into star clusters and galaxies. He deduces the motions of the bodies thus formed.

At the end of the book is a bibliography of six pages. The author gives an excellent review of what has been done on the solution of the great problem before him, with critical discussions and suggestions.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

INTERNATIONAL ASTRONOMICAL UNION

The next meeting of the International Astronomical Union will be held at Leiden, Holland, commencing July 5, 1928.

THE NEWTON BI-CENTENARY

On March 17 last, the Mathematical and Physical Society of the University of Toronto held a special meeting to commemorate the 200th anniversary of the death of Isaac Newton. There was a large attendance, and three addresses were given, as follows: "Newton's Theory of Light and its Relation to the latest Theories" by Prof. J. C. McLennan, Department of Physics; "Newton's Mathematical Work", by Prof. J. Chapelon, Department of Mathematics; and "Newton's Contribution to Astronomy" by Prof. C. A. Chant, Department of Astronomy.

PONS-WINNECKE COMET

This comet was rediscovered by Prof. George Van Biesbroeck on March 3 by means of photographs taken with the 2-foot mirror telescope. It will be less than four million miles from the earth on June 26 and will probably be visible to the unaided eye then. At that time it will be in Aquarius, in the south-eastern sky at midnight and on the meridian about 3.00 a.m. It will be near the first magnitude star Altair, in Aquila.

FROM "WALDEN" BY HENRY DAVID THOREAU

Self-emancipation even in the West Indian provinces of the fancy and imagination,—what Wilberforce is there to bring that about? Think, also, of the ladies of the land weaving toilet cushions against the last day, not to betray too green an interest in their fates! As if you could kill time without injuring eternity.

It is never too late to give up our prejudices.

MEETINGS OF THE SOCIETY

AT WINNIPEG

The regular monthly meeting of the Winnipeg Centre was held on Wednesday, December 8, at 8.15 p.m. The President, Rev. T. W. Morton was in the chair.

The following were elected to membership: Mr. Alfred Reed, Mr. R. McCalman, Mr. M. G. Greer, Mr. E. S. Clarke.

The meeting was open to the public and there was a large attendance. After extending a hearty welcome to those present, Father Morton announced that Dr. R. C. Wallace would be the speaker at the next meeting of the Society on January 12.

The President then called on Mr. H. B. Allan, who addressed the meeting, choosing as the title of his discourse "The Moon and the Planets Saturn and Jupiter".

Mr. Allan introduced his subject by saying that as our nearest neighbouring world, the moon should be a most interesting study. Viewed by the naked eye, said the speaker, the moon seemed the embodiment of peace and tranquility. Telescopes reveal a scene of desolation and catastrophe. A series of lantern slides, showing the prominent features of the surface of the moon, as seen through a telescope, depicted mountain ranges, oceans and craters.

Mr. Allan next pointed out the remarkable influence which the moon exerted on the waters of the earth, producing the tides.

Jupiter, the largest planet of the Solar System, with its nine Satellites, was discussed in a most interesting manner. Saturn with its unique ring system was also considered. Slides showing the markings of Jupiter and the rings of Saturn added to the interest of the lecture. After expressions of appreciation the meeting came to a close.

The regular monthly meeting was held on January 12, at 8.15 p.m. The President, Mrs. E. L. Taylor, was in the chair.

The paper of the evening was given by Dr. R. C. Wallace, and was entitled, "Facts and Fancies about the interior of the earth and the Heavenly Bodies."

Dealing first with fancies, Dr. Wallace outlined some of the conceptions which the ancients held about the universe. The earth, they regarded as a magnificent body quite independent, around which the sun and stars revolved. Slides were shown representing the "Centre of the World" during the height of the Deluge and the results after the waters of the Deluge had been absorbed.

Referring to the heavenly bodies, Dr. Wallace mentioned the Great Nebula in Andromeda an "inland universe" which is so distant that it takes nearly 1,000,000 years for light to travel from it to the earth. In a short discussion on the moon, the lecturer explained that there was no atmosphere and consequently no disintegration.

Dealing with the facts relating to our planet, Dr. Wallace said that from evidence furnished by volcanoes and the sinking of mines, it is known that the earth has a high internal temperature. He pointed out that there was an increase of 1° Centigrade for every 75 feet of descent, but that the increase was subject to variation. The distance from the surface of the earth to the centre was about 4,000 miles, about 1 mile of which was open to inspection. The temperature at this depth ranged about 80° Centigrade. Lava, a molten liquid, due to the heat of the earth's interior, gave some indication regarding high temperature. The average temperature of lava in a molten state is about 1,200° Centigrade.

He next spoke on Density. Our knowledge concerning the density of the earth was due to astronomers. The stone masses of the earth's crust have a density of 2.6 to 2.7. As the density of the whole earth matter is 5.5, the material towards the centre of the earth must be considerably denser, and it is believed that iron in large quantities is contained in the earth's depths.

Magnetism is another feature which the earth presesnt. The meteorites which fall on the earth indicating the composition of other bodies of the Solar System. In connection with this, Dr. Wallace explained that meteorites contained many of the minerals which are found in the crust of the earth, but more particularly iron, nickel, chromium and some of the silicates.

Experiments by Michelson and others have shown that the rigidity of the earth is at least as great as that of steel. While probably at a high temperature, the interior of the earth is apparently held rigid by the great pressure to which it is subjected. If parts are in a liquid condition, they are in that state because of a temporary relief of pressure locally, and no great part of the interior of the earth is at any one time liquid.

How continents maintained themselves was explained under the heading "Isostasy" or the science relating to the balancing of continents and oceans. Facts have been definitely established, showing that oceanic areas are more dense than continent areas and that material from beneath the ocean bed, moving sideways underneath the continental land margin, had raised the land and formed great elevations.

A vote of thanks, moved by Mr. C. E. Bastin and seconded by Dr. L. A. H. Warren, was conveyed to Dr. Wallace for his interesting lecture, after which the meeting came to a close.

S. C. Norris, *Secretary.*

[Other minutes held over to next issue]

The Royal Astronomical Society of Canada

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